

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
30 August 2001 (30.08.2001)

PCT

(10) International Publication Number
WO 01/63825 A2

(51) International Patent Classification⁷: **H04L 1/00**

(21) International Application Number: PCT/US01/02998

(22) International Filing Date: 30 January 2001 (30.01.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09/513,056 24 February 2000 (24.02.2000) US

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(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

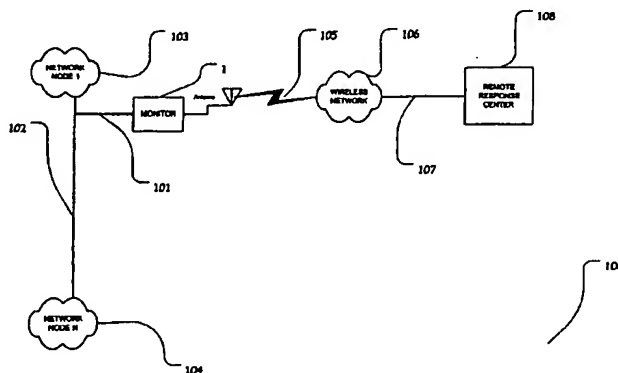
(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:

— without international search report and to be republished upon receipt of that report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: **NON-INVASIVE REMOTE MONITORING AND REPORTING OF DIGITAL COMMUNICATIONS SYSTEMS**



WO 01/63825 A2

(57) Abstract: A monitoring system for monitoring network stations or nodes for typical alert or maintenance situations, such as outages, in a digital communications network, such as a T1 circuit. A bridge can obtain performance and quality information about the nodes via a passive connection that taps into the digital communications network. A predetermined characteristic analyzer can collect performance and/or quality information output by the bridge. In response to this collected information, the predetermined characteristic analyzer can compare predetermined conditions to a threshold. In the event that the collected information exceeds or deviates from a threshold for a predetermined condition, the predetermined characteristic analyzer generates a trigger that represents a reportable event. This trigger is typically reported to a processor which, in turn, can automatically alert an individual or central monitoring station by forwarding a message regarding the reportable event via an alternate communications path, i.e., a communications path that is not a component of the existing communications network. A wireless transceiver can accept the reportable event message from the processor and transmit that message via the alternate communications path to the network management system. Significantly, this alternative communications path is not competitive with the capacity of the communications network being monitored by the network management system.

NON-INVASIVE REMOTE MONITORING AND REPORTING OF DIGITAL COMMUNICATIONS SYSTEMS

5 FIELD OF THE INVENTION

The present invention relates to non-intrusive, benign monitoring of digital communications networks for the purpose of detecting alerts at one or more nodes of the networks and alerting remote response centers via a messaging system that is distinct from the network being monitored.

10

BACKGROUND OF THE INVENTION

Information that is useful for purposes of determining the status of digital communications networks is typically collected and stored by each managed location or node of a network. This information is typically made available to a network management station via in-band protocols, such as Simple Network Management Protocol (SNMP) and Common Management Information Protocol (CMIP). SNMP and CMIP are described in "*SNMP, SNMPv2, and CMIP: The Practical Guide to Network-Management Standards*" by William Stallings, published by Addison-Wesley Publishing Company, Reading, Mass. 01857.

20 Information stored in the managed locations is typically sent in packets to the network management station within the same communications path as that being monitored. This use of monitoring channel to communicate network management information from network nodes has three distinct disadvantages. First, if the communications path is lost, the status information cannot be sent to the network management station. Second, sending the status information via the communications path that is being monitored consumes a portion of that communications path's capacity. Third, contention for the same communications path often slows the desired status reporting to unacceptable levels of delay. These characteristics of prior art network monitoring systems are significant limitations that reduce the value of

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30 monitoring a network for the users of such systems.

U.S. Patent No. 5,648,966 describes the dedication of a an existing network path as a reporting path for forwarding monitoring information to a monitoring

station. However, this patent fails to teach the use of a reporting path implemented by one or more alternate communications paths that do not compete for capacity with the communications path being monitored by the network management system. This patent also fails to teach the utilization of a wireless reporting path to facilitate rapid,
5 low cost installation.

In view of the limitations of the prior art, there exists a need to utilize alternate communications paths that do not compete for capacity with a network communications path that is monitored by a network management system. There is a further need to utilize an alternate communications path that is wireless to permit
10 cost-effective, flexible and rapid deployment of a network monitoring system.

SUMMARY OF THE INVENTION

The present invention can autonomously monitor the status of digital communications networks for the purpose of reporting quality issues to remote
15 response centers. This monitoring operation is completed by monitoring network nodes or stations in a non-intrusive, benign manner based on the use of an alternative communications path that is not part of the existing communication network. Consequently, the capacity of the communications network being monitored is not impacted by either the actions of monitoring or reporting. Moreover, the present
20 invention can accomplish this alert reporting operation in a rapid manner by utilizing an alternate, communications path, such as a wireless communications link, that does not compete with the capacity of the communications network being monitored by the network management system.

The present invention provides a monitoring system for monitoring network
25 stations or nodes for typical alert or maintenance situations, such as outages, in a digital communications network, such as a T1 circuit. A bridge can obtain performance and quality information about the nodes via a passive connection that taps into the digital communications network. A predetermined characteristic analyzer can collect performance and/or quality information output by the bridge. In
30 response to this collected information, the predetermined characteristic analyzer can compare predetermined conditions to a threshold. In the event that the collected information exceeds a threshold for a predetermined condition, the predetermined

characteristic analyzer generates a trigger that represents a reportable event. This trigger is typically reported to a processor which, in turn, can automatically alert an individual or central monitoring station by forwarding a message regarding the reportable event via an alternate communications path, *i.e.*, a communications path
5 that is not a component of the existing communications network. A wireless transceiver can accept the reportable event message from the processor and transmit that message via the alternate communications path to the network management system. Significantly, this alternative communications path is not competitive with the capacity of the communications network being monitored by the network
10 management system.

The present invention also provides a method of non-intrusively monitoring digital communications networks for detecting status information, such as maintenance issues or problems, arising in network nodes. This status information can be reported by a monitor to remote response centers, also described as network
15 management systems, via a communications path that is distinct from the communications network being monitored by the remote response centers. The monitor can collect information about one or more of the nodes of the communications network via a bridge that "taps" into the communication paths of the network. In response to detecting a deviation of collected information from one or
20 more predetermined characteristics, the monitor can generate a reporting message for delivery via the alternative communications path, typically a wireless communication path. This alternative communications path is distinct and separate from the communications network being monitored by the remote response centers.

The monitor of the present invention typically includes a monitoring device
25 for monitoring the nodes of communications paths, such as T1 circuits, and for generating event or alert messages in response to detection of an alert event in a monitored communications path. For example, the monitoring device can provide continuous non-intrusive monitoring of the quality of T1 circuits. A digital cellular communicator can be used to communicate the event messages to a network
30 administrator, control center, or other interested party via a bi-directional wireless communications link that is independent of the monitored communications paths.

For one aspect of the invention, the monitor does not require field-level programming because programming logic can be transmitted in the form of commands and data to the monitor via the wireless communications link from a remote control center. In a master unit implementation, the monitoring device can
5 monitor the operation of multiple T1 circuits and generate reporting messages to a central digital cellular communicator for subsequent transmission via the alternative wireless communications path.

For one aspect of the invention, the monitoring system can use wireless communications technology of the Cellemetry® Data Service, as described in U.S.
10 Patent Nos. 5,526,401, 5,546,444, 5,794,144, and 5,873,043, to communicate each reportable event as a data message via the overhead control channel of a cellular radiotelephone system. The referenced patents are fully incorporated by reference within this specification. Those skilled in the art will appreciate that the scope of the invention encompasses other wireless communications systems for use as an alternate
15 communication path in a monitored digital communications network.

In view of the foregoing, these and other features and advantages of the present invention may be more clearly understood and appreciated from a review of the following detailed description and by reference to the appended drawings and claims.

20

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram that shows the components of an exemplary passive monitoring unit that is physically integrated with a communications network path monitored by a network management system in accordance with an embodiment of
25 the present invention.

FIG. 2 is a block diagram that shows a passive monitoring unit deployed in a digital communications network to monitor a communications node in accordance with an embodiment of the present invention.

The accompanying drawings, which are incorporated in and constitute a part
30 of the specification, illustrate exemplary embodiments of the invention and, together with a general description given above and the detailed description below, serve to explain the principles of the invention.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

Referring now to the drawing set, in which like reference numbers throughout the several figures represent identical elements, FIG. 1 provides an illustration of the components of an exemplary passive monitoring unit that is physically integrated with a communications network path of a digital communications network monitored by a network management system. Turning now to FIG. 1, a monitor 1 comprises a bridge 2, a predetermined characteristic analyzer 3, and a discrete event interface 6. The monitor 1 also can include a processor 4, integrated within the assembly of the monitor or physically installed outside of that assembly, for controlling operations of the monitor 1.

The bridge 2 provides a high impedance, variable gain front-end for connecting or "tapping" into communications paths of the communications network to the monitor 1. The bridge can include a variable gain amplifier to compensate for insertion loss arising from placement the component on the monitored communications path. The high impedance characteristic of the bridge 2 results in a negligible current drain from the monitored communications path. The connections of the bridge 2 to the digital communications paths monitored by the monitor 1 are physically made by interfaces 7 and 8. In an exemplary embodiment, the interfaces 7 and 8 utilize an industry standard RJ48C connector to complete the connections to the bridge 2.

The digital communications paths, commonly referred to as "four wire circuits", support bi-directional communications carried by a transmit path and a receive path. Each path typically comprises a "pair" of wires, hence the term "four wire" circuit. The interface 7 can connect to the receive path of a communications network, while the interface 8 can connect to the network's transmit path. By using a high impedance connection, the bridge 2 can extract information characteristics from the communications network, as presented on the interfaces 7 and 8, without impact or interference on normal communications operations.

The output of the bridge 2 is transmitted to the predetermined characteristic analyzer 3, which preferably continuously monitors this output data stream for predetermined characteristics. Typical predetermined characteristics include "loss of

synchronization", "Bit Error Rate" or "loss of signal" on either the transmit or receive side of the interface. Additional characteristics can, optionally, be supplied by the discrete event interface 6, which can pass selected events, such as contact closures, tamper switches, temperature thresholds and limit switches, on the monitor interface 9 and the control interface 10. As will be described in more detail below with respect to FIG. 2, the interfaces 7, 8 and 9 can be collectively viewed as a single interface to the monitor 1, such as the interface 101 shown in FIG. 2. In summary, information representing predetermined characteristics can be supplied to the predetermined characteristic analyzer 3 via the output of the bridge 2 or the discrete event interface 6.

To determine a reportable event, the predetermined characteristic analyzer 3 can compare a predetermined characteristic output by either the bridge 2 or the discrete event interface 6 to a threshold. In the event that the predetermined characteristic deviates from the threshold, the predetermined characteristic analyzer 6 identifies a reportable event for the communications network. Upon detection of a reportable characteristic, the predetermined characteristic analyzer 3 notifies the processor 4 via a link extending between the monitor 1 and the processor 4. In turn, the processor 4 can prepare a report message and forwards that message to a wireless transceiver 5 for transmission to a remote response center, also known as a network management system, of the digital communications system.

The monitor 1 can use aspects of the Cellemetry® Data Service, as described in U.S. Patent Nos. 5,526,401, 5,546,444, 5,794,144, and 5,873,043, to communicate each reportable event as a data message via the overhead control channel of a cellular radiotelephone (CMR) system. The data message system described in the referenced U.S. patents includes data reporting devices, at least one mobile switching center (MSC), and a data collection system connected directly or indirectly to the MSC or a Signal Transfer Point (STP). For the monitoring application of the present invention, the wireless transceiver 5 is implemented as one of the data reporting devices described in the referenced patents. The data reporting device can transmit a data message containing selected data via a cellular network control channel of the CMR system when the data reporting device first identifies itself or "registers" for operation with the MSC. Alternatively, the data reporting device can send the selected data via

the cellular network control channel in a data message formatted to represent a "call origination" signal. In turn, the MSC can send the data message to the data collection system via a communications link. In this manner, the data message system takes advantage of an installed base of cellular communications equipment by using the cellular network control channel for data communications between a central location and one or more remote sites.

Those skilled in the art will appreciate that the scope of the invention encompasses other wireless communications systems for use as an alternate communication path in a monitored digital communications network. For example, a dedicated cell-based wireless communications system can be used to carry the event message between the monitor 1 and a remote response center. Likewise, a bi-directional radiopaging system can be used to support the transportation of the event message from the monitor 1 to the remote response center. Yet another wireless communications media is the SMS capability of many cellular mobile radiotelephone systems.

Although the monitor 1 comprises several components shown as discrete physical elements in FIG. 1, it will be understood that the monitor may also be configured as a single homogenous physical unit with some or all functions emulated in software or by a combination of electronic devices and software.

Those skilled in the art will further understand that the scope of the invention can include a modular assembly of components of the monitor 1. For this modular component embodiment, the assemblage of the bridge 2, predetermined characteristic analyzer 3 and discrete event interface 6 can be integrated within a single assembly 12. This modular assembly approach enables the processor 4 to interface with multiple monitors 1, thus lowering costs in some installations based upon a master unit implementation that uses a single processor to control multiple monitors. A communications link 11 can connect the processor to other monitors 1 for this master unit implementation of the monitoring system.

Referring now to FIG. 2, the operating environment for one or more monitors 1 typically comprises multiple nodes 103 and 104 in a communications system, such as a digital telecommunications system, having one or more communication paths 102. A monitor 1 can be connected to a single node, such as the network node 103, or

to "n" nodes via a connection 101. The connection 101 is typically connected between a network node and the interfaces 7, 8 and 9 of the monitor 1 shown in Fig. 1. In response to detecting a reportable event for a monitored node, the monitor 1 can generate an event message for transmission via a wireless communications path 105
5 and a wireless network 106. The combination of the wireless communication path 105 and the wireless network 106 is separate and independent of the monitored communications path 102, which is typically implemented by a wired T1 circuit. The wireless network 106 can forward the event message to the remote response center 108 via the communications link 107.

10 In addition to detecting and reporting predetermined characteristic events, the present invention also provides a mechanism to remotely and wirelessly direct discrete control operations that are local to the operating environment of the monitor 1. A command message emanating from remote response center 108 can be conveyed via the data communications link 107, wireless network 106, and the wireless link 105
15 to the monitor 1. The discrete event interface 6 of FIG. 1 can be implemented by a generalized, switch closure interface, which is applicable to any control that can be activated by a switch contact closure. The command received by the monitor 1 can operate relay contacts in discrete event interface 6, thereby altering electrical continuity between the controlled device and the control interface 10. In this manner,
20 remote control of a controllable device operating in the environment of a monitor 1 can be achieved via the discrete event interface 6 and the control interface 10.

It should be understood that the particular embodiments described herein have been disclosed by way of example and that other modifications may occur to those skilled in the art without departing from the scope and spirit of the appended claim
25 set.

CLAIMS

What is claimed is:

- 5 1. A method of non-intrusively monitoring a communications network for detection of a predetermined characteristic and alerting a remote response center via an alternate communications path that is distinct from the monitored communications network, comprising the steps,
- obtaining information from a node in the communications
- 10 network;
- generating an event report if the predetermined characteristic of the obtained information deviates from a threshold; and
- transmitting the event report via the alternate communications path that is distinct from the communications network being monitored.
- 15 2. The method of Claim 1, wherein the alternate communications path comprises a wireless network and the digital communications network comprises a separate and independent wired network.
- 20 3. The method of Claim 1, wherein the step of obtaining information from a node in the communications network comprises using a high impedance, variable gain connection to tap to the node of the communications network.
- 25 4. The method of Claim 1, wherein the step of obtaining information from a node in the communications network comprises using a bridge to connect to the communications network, the bridge comprising a variable gain amplifier to compensate for insertion loss arising from placement of the bridge in the communications network.

30

5. The method of Claim 4, wherein the step of obtaining information from a node in the communications network further comprises transmitting the information output by the bridge to a predetermined characteristic analyzer to identify the predetermined characteristic representing an event.

5

6. The method of Claim 4, wherein the step of generating an event report further comprises:

comparing the predetermined characteristic to the threshold with a predetermined characteristic analyzer coupled to the bridge; and

10 if the predetermined characteristic deviates from the threshold, then

identifying an event, and

preparing the event report containing the event with a processor coupled to the predetermined characteristic analyzer.

15

7. The method of Claim 1, wherein the step of generating an event report comprises:

comparing the predetermined characteristic to the threshold;

if the predetermined characteristic deviates from the threshold,

20 then

identifying an event, and

preparing the event report containing the event.

8. The method of Claim 1, wherein the step of transmitting the event report via the alternate communications path comprises transmitting a report message comprising the event report to a remote response center coupled to the alternate communications path.

9. A computer-readable medium having computer-executable instructions for performing the steps recited in Claim 1.

30

10. A method of non-intrusively controlling a controllable device via an alternate communications path that is distinct from a monitored communications network, comprising the steps:

5 using a monitor to collect information from the communications network, the monitor operative to transmit an event report to a remote response center via the alternate communications path if a predetermined characteristic of the collected information deviates from a threshold;

transmitting a control signal from the remote response center to the monitor via the alternate communications path; and

10 performing a control operation by the controllable device in response to processing the control signal at the monitor.

11. The method of Claim 10, wherein the alternate communications path comprises a wireless network and the communications network comprises a
15 separate and independent wired network.

12. The method of Claim 11, wherein the step of processing the control signal comprises decoding the control signal to generate an instruction for output to a discrete event interface of the monitor, the discrete event interface
20 operative to initiate the control operation in response to the instruction.

13. The method of Claim 12, wherein the discrete event interface comprises a switch closure interface having relay contacts controllable upon receipt of the instruction.
25

14. The method of Claim 10, wherein the step of performing a control operation comprises controlling the state of relay contacts at the monitor in response to the control signal, the relay contacts controlling electrical continuity between the monitor and the controllable device.
30

15. A computer-readable medium having computer-executable instructions for performing the steps recited in Claim 10.

16. A monitor for non-intrusively monitoring a communications network, comprising:

a bridge, coupled to the communications network, operable for collecting information from the communications network;

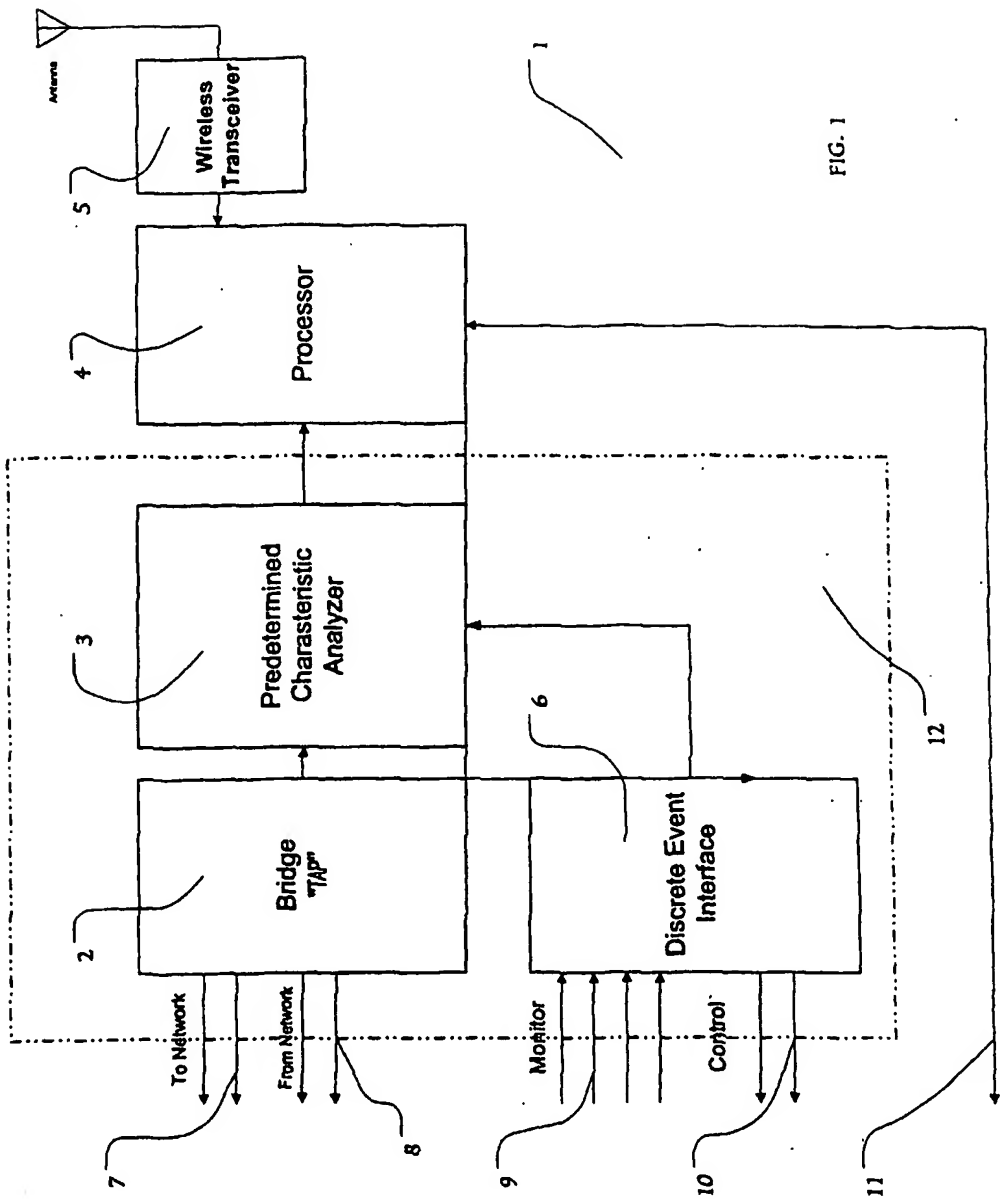
5 a predetermined characteristic analyzer operative to detect a predetermined characteristic in the information output by the bridge;

a processor, coupled to the predetermined characteristic analyzer, operative to generate an event report if the predetermined characteristic deviates from a threshold; and

10 a transmitter, coupled to the processor, for sending the event report to a remote response center via an alternative communications path distinct from the communications network.

17. The system of Claim 16, wherein the monitor further comprises

15 a discrete event interface, coupled to the predetermined characteristic analyzer, operable for collecting information from the communications network and receiving instructions from the remote response center via the alternative communications path and performing a control operation on the communications network in response to the instruction.



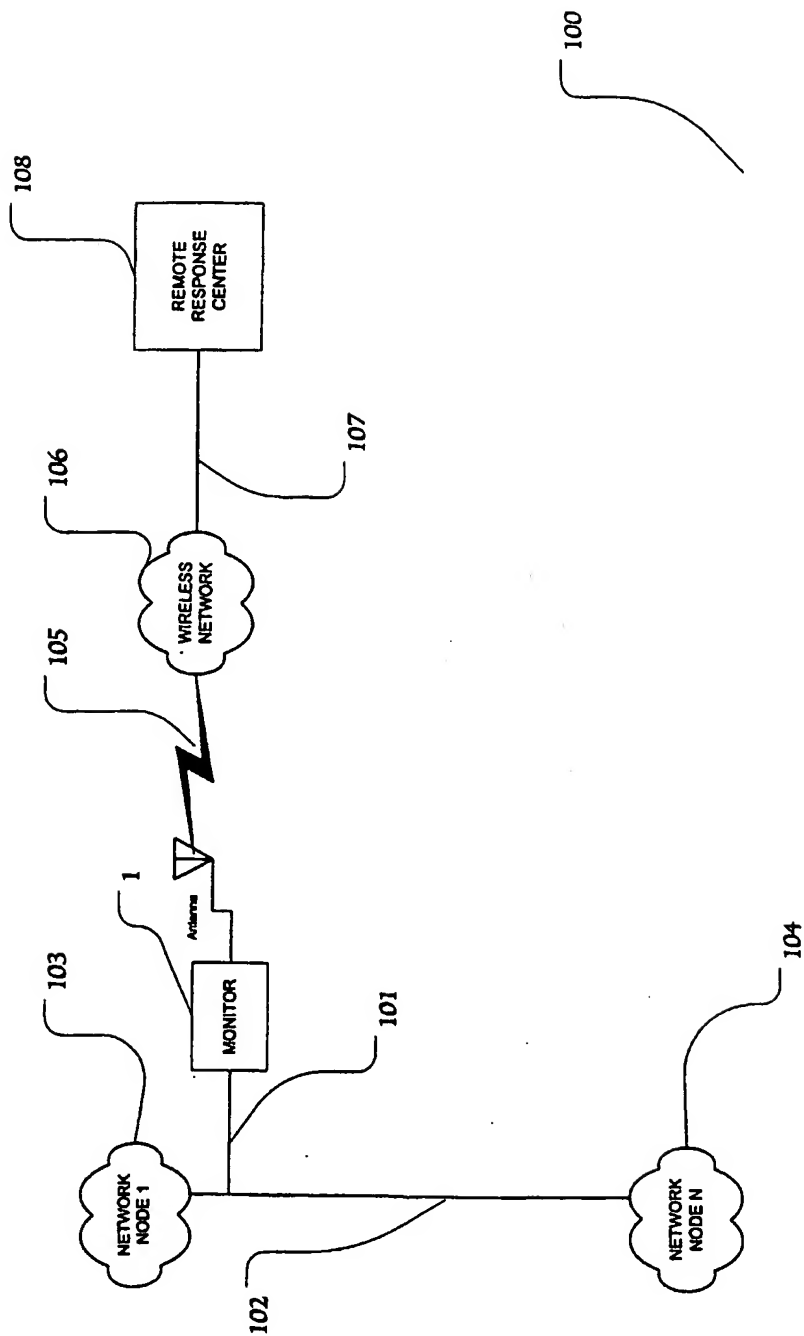


FIG. 2